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## Description

The present invention relates to a device for controlling a motor vehicle to run at a constant speed, and more particularly to a device for controlling a motor vehicle to run at a constant speed while reducing overshooting of a vehicle speed at the time of a transition from the running on an uphill to the running on a flat road.

To keep, at a constant level, the speed of travel of a motor vehicle which is continuously running on a flat road or a sloping road, the driver has to adjust the depth to which an accelerator pedal is depressed according to the road conditions, a procedure which is physically and mentally tiresome. There has recently been developed a device, known as a cruise control system, for controlling a motor vehicle to run at a desired constant speed without requiring the driver to depress and adjust the accelerator pedal.

With the conventional constant-speed controlling device, when a large-size motor vehicle of a large inertial mass runs uphill and then on a flat road, as shown in Fig. 5(a) of the accompanying drawings, the actual speed of the motor vehicle overshoots a preset vehicle speed as shown in Fig. 5(c). If such an overshoot is large, the driver and passengers on the vehicle feel uncomfortable, and the motor vehicle tends to shake vertically, causing the load on the motor vehicle to collapse.

The problem of overshooting is particularly experienced by a diesel-engine motor vehicle in which an all-speed governor is mounted on a fuel injection pump as a fuel supply device.

The reason for an increased amount of overshooting on such a motor vehicle in a constant-speed running mode is that, as shown in Fig. 5(c), while running uphill, the control lever of the governor is opened to a full-speed position, and a large time lag or delay is consumed before the control lever returns to an opening A corresponding to a preset speed when the vehicle runs on a flat road. In a system in which the opening of a governor control lever is subject to proportional plus integral control (PI control) based on the difference between a preset speed and an actual speed, increased overshooting is caused because the term of integral control is increased and a large time lag elapses until the control lever returns to the opening A. More specifically, as shown in Fig. 6, in order for the motor vehicle to run over an uphill, the opening B is sufficient as the control lever opening which keeps an engine rotational speed  $N_b$  at which an engine torque  $T_b$  can be produced (during uphill running, the transmission is in a lower gear position than the gear position in which the vehicle runs on a flat road with the lever opening A). Therefore, the hatched area shown in Fig. 5(c) indicates wasteful motion of the control lever in the conventional constant-speed controlling device.

One proposed device for controlling a motor vehicle to run at constant speed is disclosed in Japanese Laid-Open Patent Publication No. 60-145430. The disclosed device utilizes auxiliary braking provided by exhaust braking as means for reducing speed overshooting of a large-size motor vehicle having a large inertial mass.

The disclosed scheme is however not addressed to the elimination of the wasteful motion of the control lever, but to the solution of the problem of overshooting caused by the control lever opened to the full-speed position by effecting auxiliary braking provided by exhaust braking. Therefore, the problems of excessive fuel consumption and a complex mechanism remain to be solved.

EP-A-0154029 discloses a device for regulating the speed of a vehicle, the device being able to store one or two desired speeds and calculate the actual vehicle speed, the operator being able to switch easily between the preset desired speeds.

It is an object of the present invention to provide a device for controlling a motor vehicle to run at a constant speed while reducing overshooting of a vehicle speed at the time of constant-speed running.

Another object of the present invention is to provide a device for controlling a motor vehicle to run at a constant speed while improving fuel economy.

According to the present invention, a constant-speed controlling device for controlling a vehicle to run at a constant speed including an electronic controller for controlling a device for supplying fuel to an engine which drives the vehicle, based on the difference between a preset constant speed at which the vehicle is to run and a speed at which the vehicle is running, the constant-speed controlling device comprising : means for detecting the speed at which the vehicle is running ; and, means for setting the preset constant speed at which the vehicle is to run ; is characterised by :

means for calculating a target engine rotation speed based on the preset speed and gear position of a transmission of the vehicle while it is running ; means for calculating an upper limit for the amount of fuel to be supplied for maintaining the target engine rotation speed ; proportional plus integral control means for calculating the amount of fuel to be supplied based on the preset speed and the speed at which the vehicle is running ; and, means for interrupting integral control of the proportional plus integral control means when the amount of fuel which is calculated by the proportional plus integral control means to be supplied becomes greater than the upper limit.

The above and other objects, features and advantages of the present invention will become more apparent from the following description when taken in conjunction with the accompanying drawings in which a preferred

embodiment of the present invention is shown by way of illustrative example.

Fig. 1 is a block diagram of a constant-speed controlling device for a motor vehicle according to an embodiment of the present invention ;

Fig. 2 is a further block diagram of the constant-speed controlling device for a motor vehicle according to the embodiment of the present invention ;

Fig. 3 is a flowchart of an operation sequence of the constant-speed controlling device ;

Fig. 4 is a graph explaining how an upper limit for control lever opening is determined ;

Figs. 5(a), 5(b), and 5(c) are diagrams explaining the problem of a conventional constant-speed controlling device ; and,

Fig. 6 is a graph showing the relationship between engine rotational speeds and torques.

As shown in Fig. 1, an engine 1 is supplied with fuel from a fuel injection pump 2 serving as a fuel supply device and controlled by a governor (all-speed governor) 3 which is controlled by a control lever 4. The control lever 4 can be actuated by a step motor 5 for varying its opening from a zero-speed position indicated by the solid line to a full-speed position indicated by the broken line. The opening of the control lever 4 can be controlled by the step motor 5 dependent on the depth to which an accelerator pedal 6 is depressed. Denoted at 7 is a gear selector lever or shift lever. An electronic controller 8 comprising a microcomputer or the like includes a memory for storing a normal transmission control program for determining an optimum transmission gear position from a vehicle speed and the amount of depression of the accelerator pedal 6, a clutch control program for controlling a clutch during transmission control, a program for a constant-speed controlling device, and other programs required for vehicle running, a control unit for executing these programs, and an input/output circuit.

A friction clutch 9 is selectively engaged and disengaged by a clutch actuator 10. A normally meshing transmission 11 has an output shaft 12 and is operated for its shifting and selecting operation by a transmission actuator 13. The rotational speed of the engine 1 is detected by an engine rotation sensor 1a. The opening of the control lever 4 is detected by a lever opening sensor 4a. The amount of depression of the accelerator pedal 6 is detected by a depression sensor 6a. The select position of the selector lever 7 is detected by a select position sensor 7a. The gear position of the transmission 11 is detected by a gear position sensor 11a. The vehicle speed is detected by a vehicle speed sensor 11b from the rotational speed of the output shaft 12 of the transmission 11. A desired vehicle speed can be set in a constant speed mode by a set switch 14. Output signals from these sensors and the set switch 14 are applied to the electronic controller 8, which then produces output signals to automatically control the step motor 5, the clutch actuator 10, and the transmission actuator 13 dependent on the running conditions of the vehicle. The electronic controller 8 stores data on the total displacement of the engine, the final drive ratio, the weights of the vehicle (when loaded and not loaded), the tire radius, the transmission gear ratios, etc.

Operation of the constant-speed controlling device according to the present invention will be described with reference to the flowchart of Fig. 3.

In a step P1, a preset vehicle speed V1 set by the set switch 14 is read into a memory in the electronic controller 8. A target engine rotational speed N1 is calculated from the preset vehicle speed V1 and the gear ratio at the present gear position of the transmission 11 in a step P2.

Then, the resistance to the running of the vehicle is calculated in a step P3 from the rate of change of the engine rotational speed by the following equation, for example :

Resistance to running = Engine output - Force used for acceleration/deceleration

The above equation can be expressed, using the shaft average effective pressure of the engine, as follows :

$$P_{mer} = P_{me} - Kx \frac{W}{V_s} x \left( \frac{R}{\mu f} \right)^2 x \left( \frac{1}{\mu t_i} \right)^2 x \frac{\Delta N_e}{\Delta t}$$

where

$P_{mer}$  : the shaft average effective pressure of the engine (engine output),

$K$  : a constant,

$V_s$  : the total displacement of the engine,

$W$  : the weight of the vehicle,

$R$  : the tire radius,

$\mu f$  : the final drive ratio,

$\mu t_i$  : the transmission gear ratio, and

$\Delta N_e / \Delta t$  : the change in the engine rotational speed in a time  $\Delta t$ .

As shown in Fig. 4, the target engine rotational speed N1 is an engine rotational speed at which a torque T1 is produced that can generate a driving force for overcoming the resistance R to the running of the vehicle.



Optimum target engine rotational speeds (e.g.,  $N_a - N_e$ ) for the respective gear positions of the transmission are calculated. Then, an upper limit control lever opening Lever (Max) capable of keeping the target engine rotational speed  $N1$  is determined in a step P4. In Fig. 4, assuming that the present resistance to the running of the vehicle is  $R$ , the target engine rotational speed  $N1$  can be kept at the control lever openings  $c$ ,  $d$ , and  $e$ .

5 The lower limit lever opening  $c$  which gives a minimum amount of fuel to be supplied is determined from a map 20 as shown in Figure 2 as the upper limit control lever opening Lever (Max) which serves as the upper limit for the amount of fuel to be supplied. In a next step P5, the control lever opening is calculated by proportional plus integral control (PI control) from the difference between the actual vehicle speed  $V_r$  and the preset vehicle speed  $V1$ . The control lever opening thus calculated and the upper limit control lever opening Lever (Max) are then compared in a step P6. If the calculated control lever opening is larger than Lever (Max), i.e., if YES, then integral control in the PI control is interrupted in a step P7, and the vehicle is controlled to run by controlling the control lever based on a PI control signal produced while the integral control is being interrupted. More specifically, as shown in Fig. 2, the control lever opening calculated in the PI control and the upper limit control lever opening Lever (Max) determined from the map 20 are compared in a comparator 21. If the control lever opening

10 calculated in the PI control is larger than Lever (Max) from the map, then operation of an integrator 22 for the I control of the PI control is stopped, and the control lever opening is controlled based on the PI control signal. Thus, the control lever opening is controlled while limiting the term of integral control in the PI control.

If the control lever opening calculated in the PI control is smaller than Lever (Max) from the map in the step P6, then the vehicle is controlled to run with the calculated control lever opening in a step P8. The control lever opening is thus controlled to be smaller than the upper limit, i.e. lever (Max).

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With the device for controlling the vehicle to run at constant speed according to the present invention, as described above, the opening of the control lever of the governor of the fuel injection pump which serves as the device for supplying fuel to the engine is limited below a certain upper limit according to running conditions, or the term of integral control in PI control is limited dependent on running conditions. Therefore, the time (time lag or delay), required for the control lever to return upon a transition from the running on an uphill to the running on a flat road is shorter than that in a conventional constant-speed controlling device in which the control lever is opened to the full-speed position. Accordingly, overshooting of the vehicle speed at the time of vehicle transition from the running on an uphill to the running on a flat road is reduced, and fuel economy is improved since the control lever is not opened more than necessary.

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## Claims

1. A constant-speed controlling device for controlling a vehicle to run at a constant speed including an electronic controller (8) for controlling a device (3) for supplying fuel to an engine (1) which drives the vehicle, based on the difference between a preset constant speed ( $V1$ ) at which the vehicle is to run and a speed ( $V_r$ ) at which the vehicle is running, the constant-speed controlling device comprising :

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means (11b) for detecting the speed at which the vehicle is running ; and, means (14) for setting the preset constant speed at which the vehicle is to run ; characterised by :

40 means (8) for calculating (P2) a target engine rotation speed ( $N1$ ) based on the preset speed and gear position of a transmission of the vehicle while it is running ; means (8) for calculating (P4) an upper limit (Lever (max)) for the amount of fuel to be supplied for maintaining the target engine rotation speed ; proportional plus integral control means for calculating the amount of fuel to be supplied based on the preset speed ( $V1$ ) and the speed ( $V_r$ ) at which the vehicle is running ; and, means for interrupting (P7) integral control of the proportional plus integral control means when the amount of fuel which is calculated by the proportional plus integral control means to be supplied becomes greater than the upper limit.

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2. A device according to claim 1, wherein the fuel supplying device comprises a fuel injection pump having an all-speed governor.

3. A device according to claim 1 or claim 2, wherein the upper limit (Lever (max)) is calculated on the basis of the target engine rotation speed ( $N1$ ) and the resistance to the running of the vehicle.

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## Ansprüche

55 1. Eine Tempomat-Vorrichtung zur Steuerung einer konstanten Fahrgeschwindigkeit eines Fahrzeuges einschließlich einer elektronischen Steuereinheit (8) zur Steuerung eines Gerätes (3) zur Versorgung eines Motors (1) mit Kraftstoff, der das Fahrzeug antreibt, auf der Grundlage der Differenz zwischen einer vorgewählten, konstanten Geschwindigkeit ( $V1$ ), bei der das Fahrzeug gefahren werden soll, und einer Geschwindigkeit

(Vr), mit der sich das Fahrzeug bewegt, wobei die Tempomat-Vorrichtung umfaßt :

Mittel (11b) zur Feststellung der Geschwindigkeit, mit der sich das Fahrzeug bewegt, und Mittel (14) zum Festsetzen der vorgewählten, konstanten Geschwindigkeit, mit der das Fahrzeug bewegt werden soll, gekennzeichnet durch :

5 Mittel (8) zur Berechnung (P2) einer Ziel-Motordrehzahl (N1) auf der Grundlage der vorgewählten Geschwindigkeit und der Gangposition eines Getriebes des Fahrzeuges, während es fährt, Mittel (8) zur Berechnung (P4) eines oberen Grenzwertes (Lever (max)) für die zuzuteilende Kraftstoffmenge zur Beibehaltung der Ziel-Motordrehzahl, proportionale und zusätzlich integrale Reglermittel zur Berechnung der zuzuteilenden Kraftstoffmenge auf der Grundlage der vorgewählten Geschwindigkeit (V1) und der  
10 Geschwindigkeit (Vr), mit der sich das Fahrzeug bewegt, und durch Mittel zur Unterbrechung (P7) der integralen Regelung der proportionalen und zusätzlich integralen Regelungsmittel, wenn der zuzuführende Kraftstoffbetrag, der durch die proportionalen und gleichzeitig integralen Regelungsmittel berechnet wird, größer wird als der obere Grenzwert

2. Eine Vorrichtung nach Anspruch 1, bei der das Kraftstoffversorgungsgerät eine Kraftstoffeinspritzpumpe  
15 umfaßt, die einen Drehzahlregler aufweist.

3. Eine Vorrichtung nach Anspruch 1 oder 2, bei der der obere Grenzwert (Lever (max)) auf der Basis der Ziel-Motordrehzahl (N1) und dem Fahrwiderstand des Fahrzeuges berechnet wird.

## 20 Revendications

1. Dispositif régulateur de vitesse constante permettant la conduite d'un véhicule à vitesse constante comportant un régulateur électronique (8) de commande d'un dispositif (3) d'apport de carburant au moteur (1) du véhicule, basé sur la différence entre une vitesse constante programmée (V1) à laquelle le véhicule doit  
25 se déplacer et la vitesse effective (Vr) du véhicule, ledit régulateur de vitesse de véhicule prévoyant :

des moyens capteurs (11b) de vitesse de conduite du véhicule ; et des moyens régulateurs (14) de vitesse constante programmée à laquelle le véhicule doit se déplacer ; caractérisé par :

des moyens (8) de calcul (P2) de vitesse-cible (N) de rotation de moteur basés sur la vitesse programmée et la sélection à la boîte de vitesse de transmission du véhicule lors de sa conduite ; des moyens (8) de  
30 calcul (P4) d'une limite supérieure (« maxi »-levier) d'apport de carburant pour maintenir la vitesse-cible de rotation du moteur ; des moyens de régulation proportionnelle et intégrale de calcul d'apport de carburant à prévoir basé sur la vitesse-programmée (V1) et la vitesse (Vr) de conduite du véhicule ; et des moyens pour interrompre la régulation intégrale de commande proportionnelle et intégrale lorsque l'apport de carburant calculé par les moyens de commande proportionnelle et intégrale d'apport à prévoir dépasse la  
35 limite supérieure.

2. Dispositif suivant la revendication 2, selon lequel le dispositif d'apport de carburant comporte une pompe d'injection de carburant ayant un gouverneur global des vitesses.

3. Dispositif suivant les revendications 1 ou 2, selon lequel la limite supérieure (« maxi » levier) est calculée sur la base de la vitesse-cible (N1) de rotation du moteur et la résistance de conduite du véhicule.

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Fig. 1

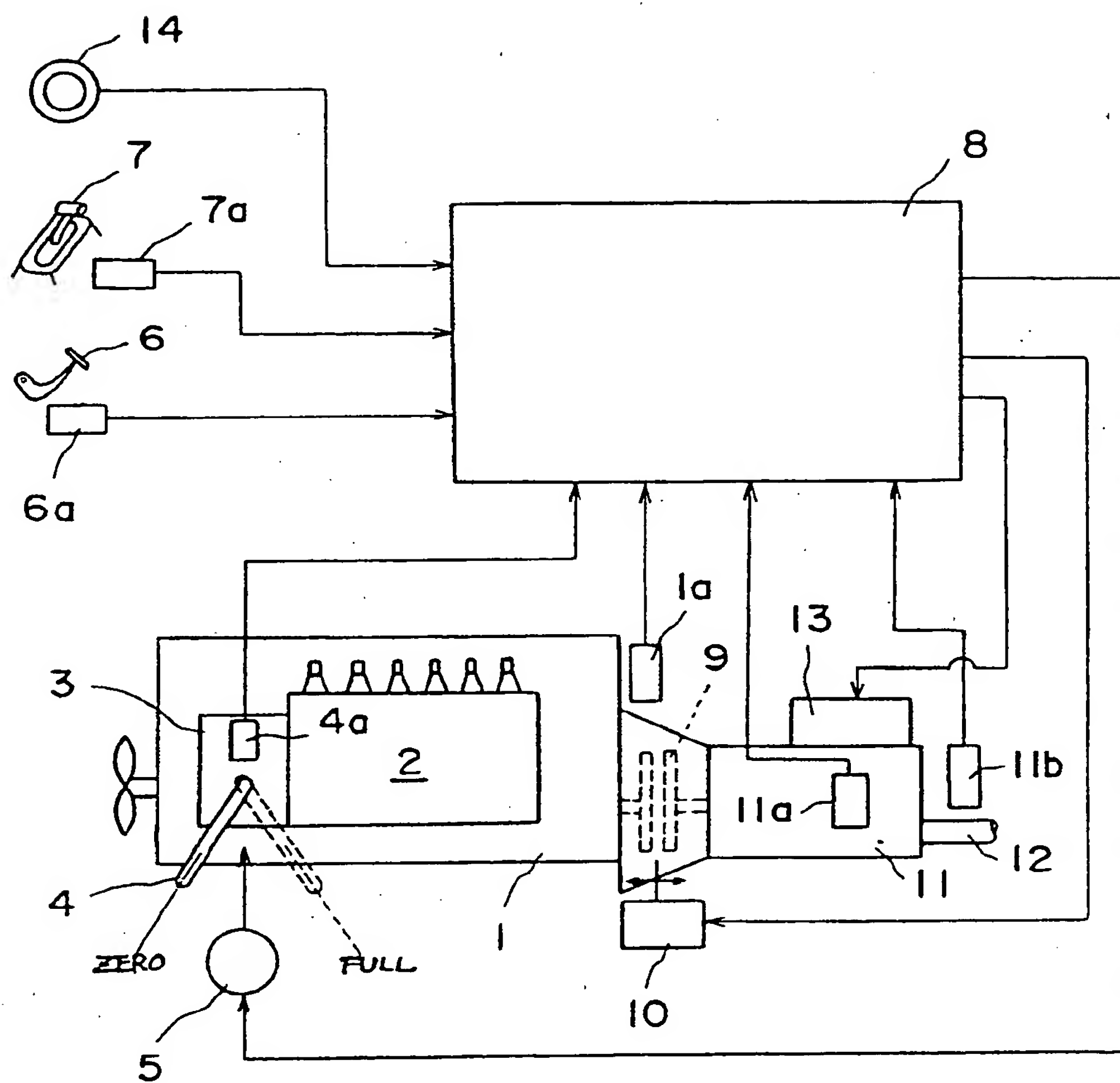


Fig. 2

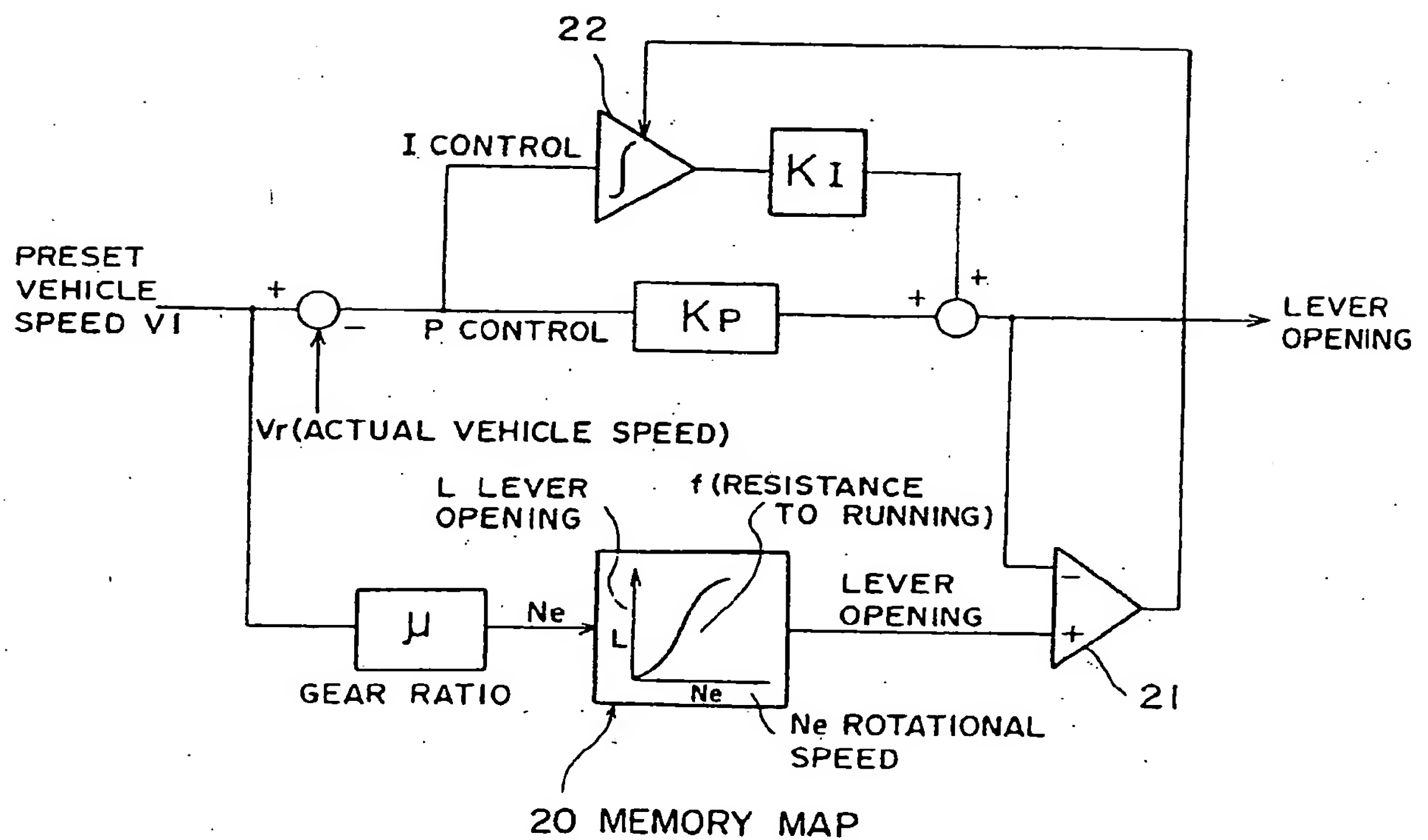


Fig. 3

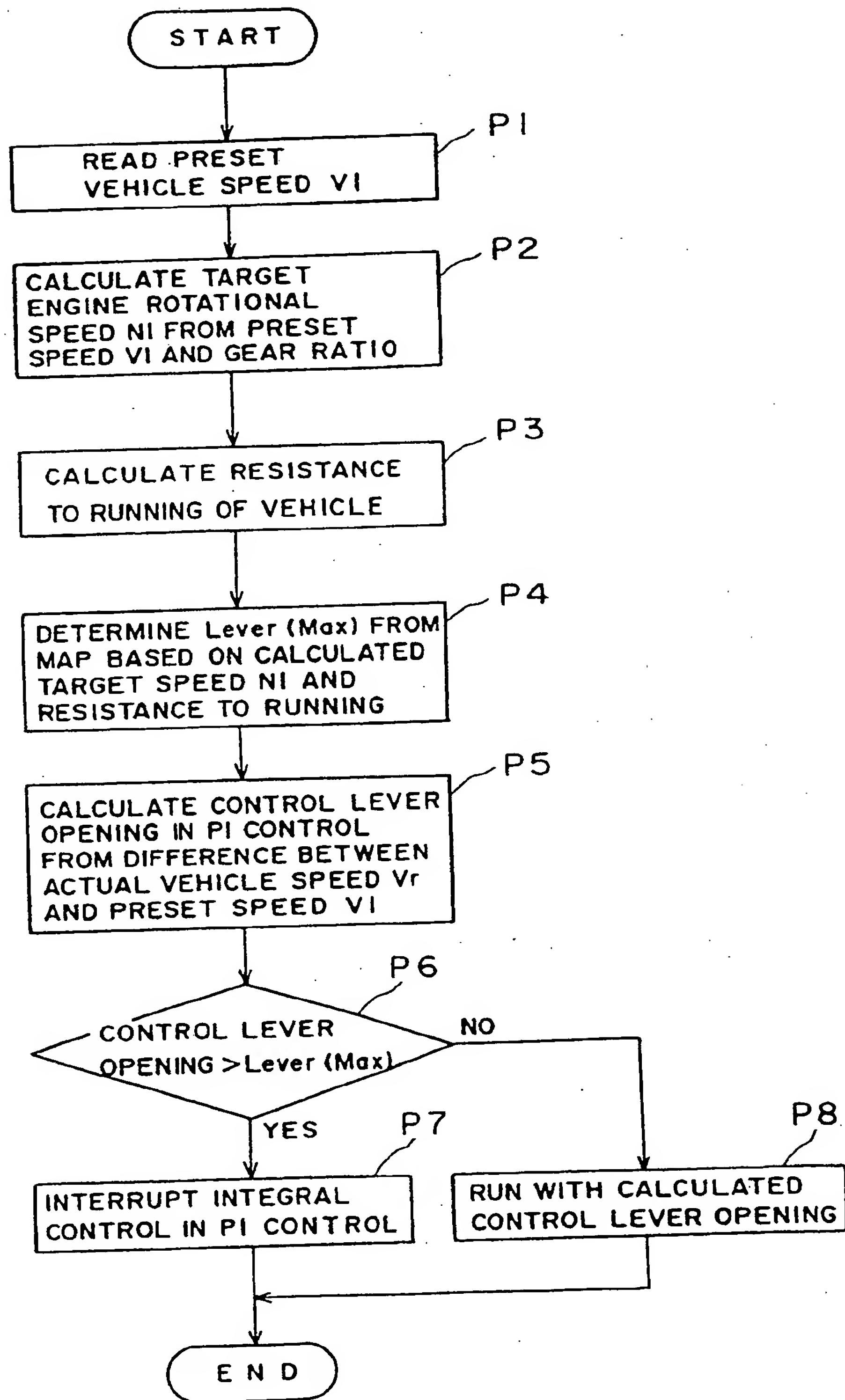




Fig. 4

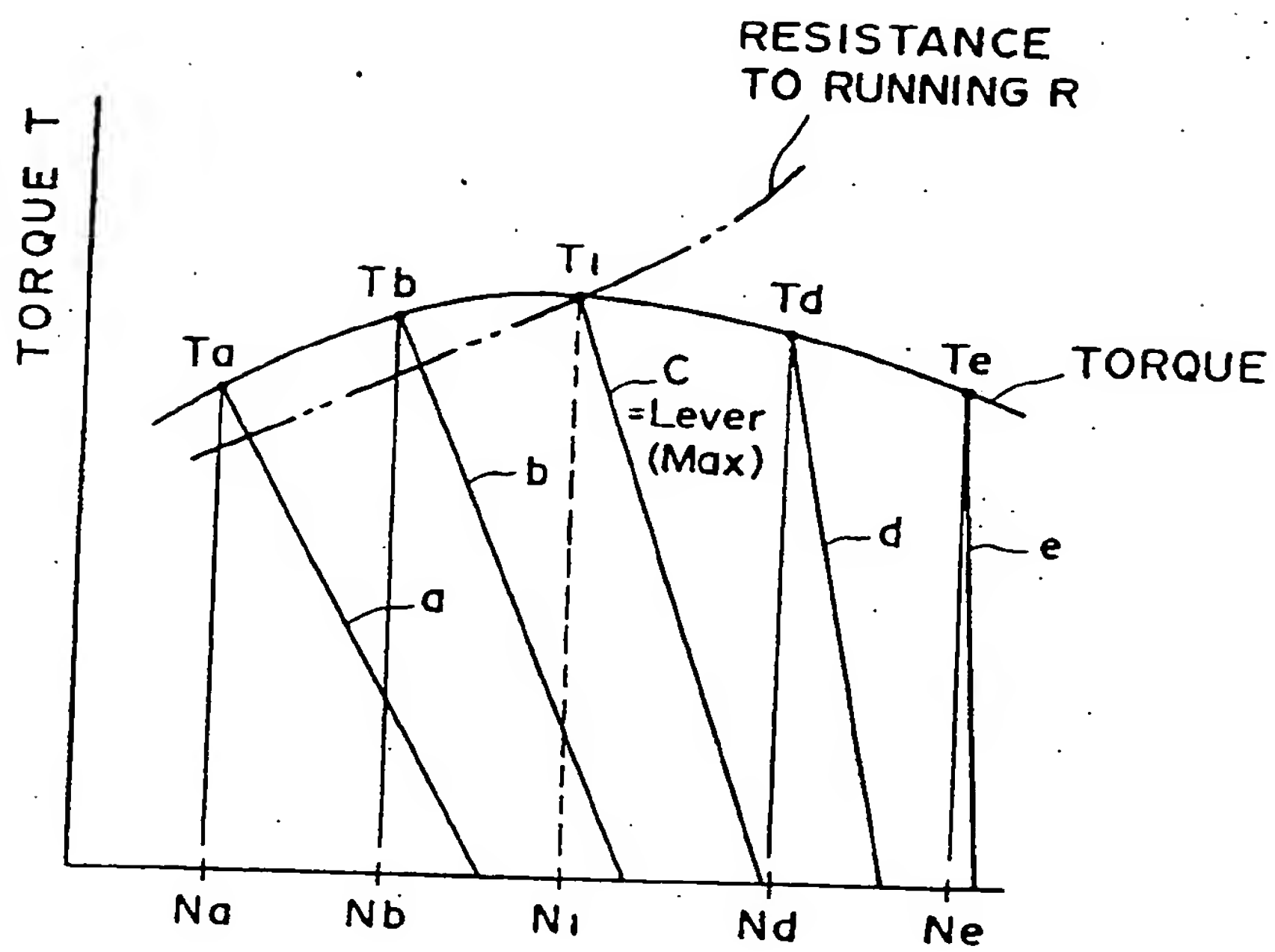


Fig. 5

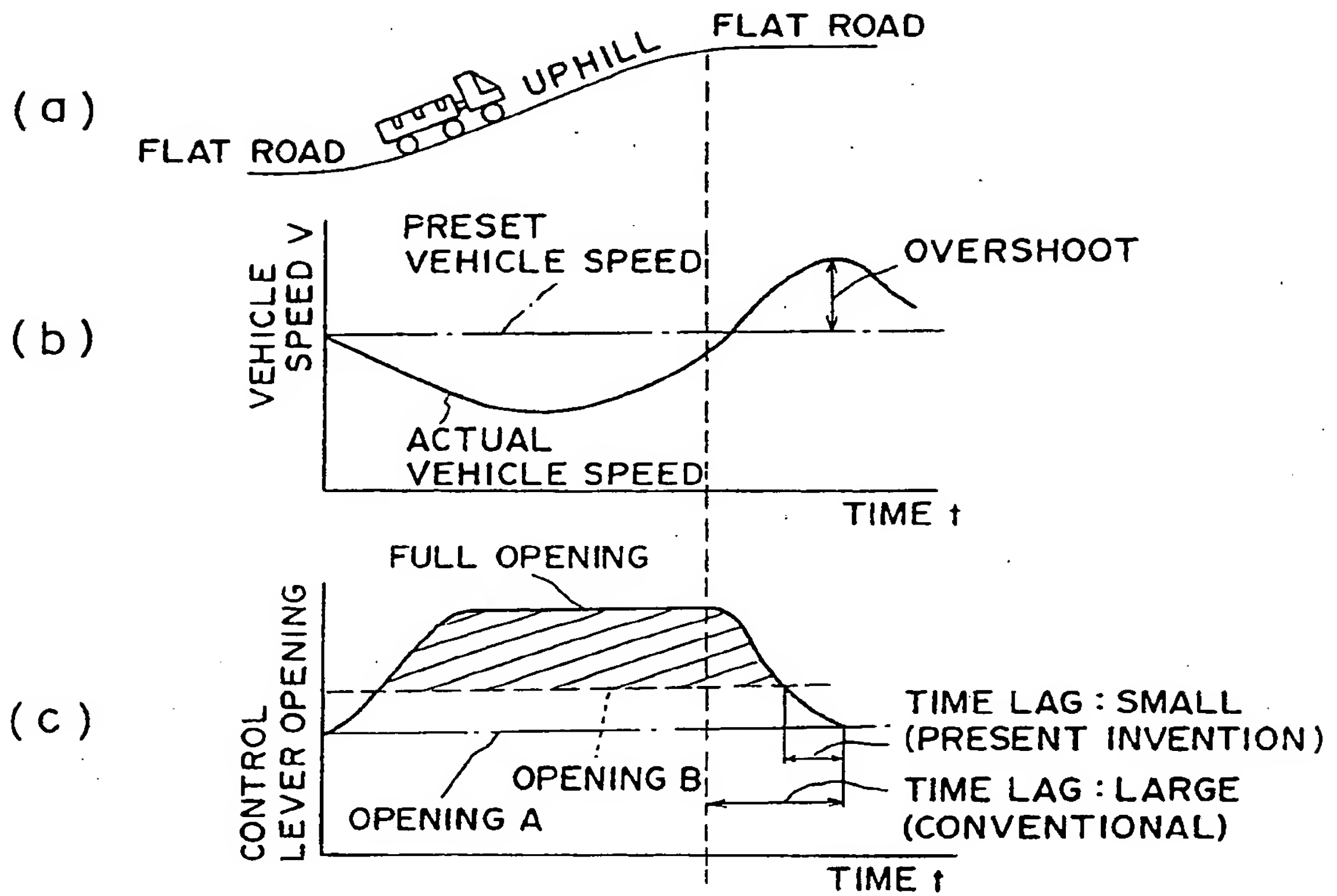


Fig. 6

